Wm Marshall.

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THE

MAIN-DRAINAGE SCHEMES

FOR

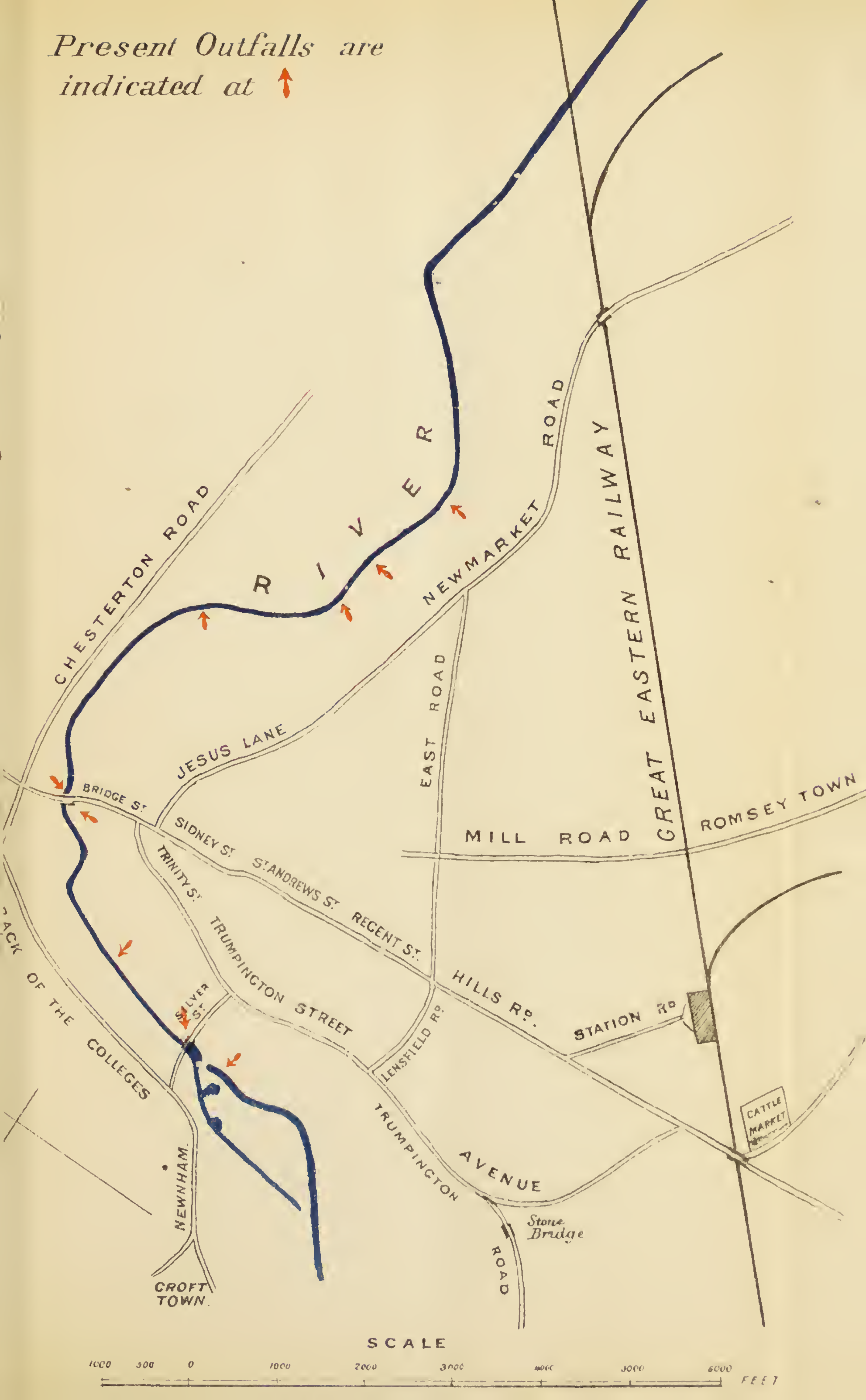
CAMBRIDGE

DESCRIBED AND ILLUSTRATED BY

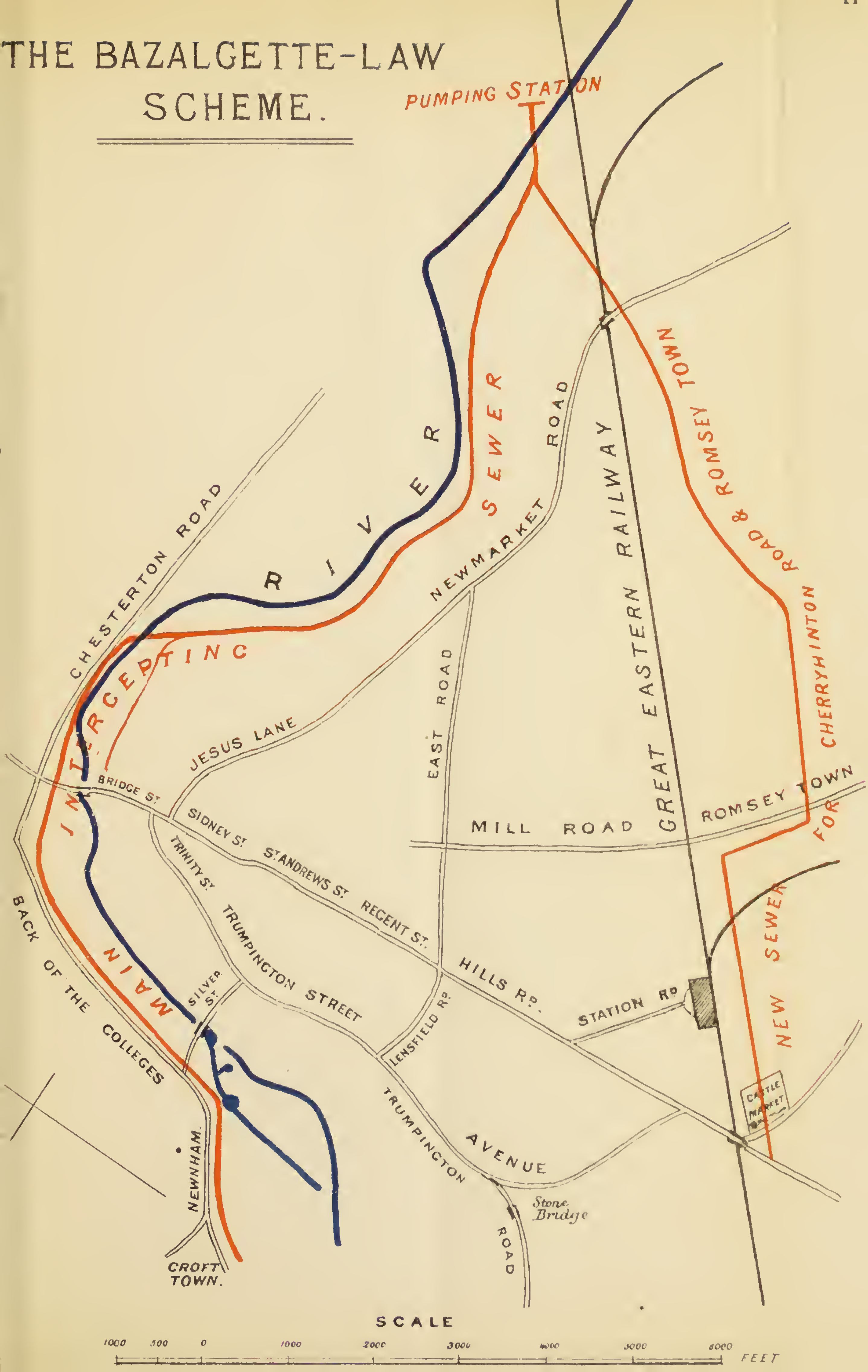
CHARLES TURNER,

A MEMBER OF THE URBAN SANITARY AUTHORITY.

Cambridge :
REDIN & CO., 16, TRINITY STREET.
1886.


Present Outfalls are indicated at ↑
RIVER
CHESTERTON ROAD
NEWMARKET ROAD
GREAT EASTERN RAILWAY
JESUS LANE
BRIDGE ST
SIDNEY ST
ST ANDREWS ST
REGENT ST
HILLS RD.
EAST ROAD
MILL ROAD
ROMSEY TOWN
TRINITY ST
TRUMPINGTON STREET
SILVER ST.
LENSFIELD RD
STATION RD
CATTLE MARKET
BACK OF THE COLLEGES
NEWNHAM.
CROFT TOWN.
TRUMPINGTON AVENUE
TRUMPINGTON ROAD
Stone Bridge
SCALE
1000 500 0 1000 2000 3000 4000 5000 6000
FEET

THE BAZALGETTE-LAW SCHEME.



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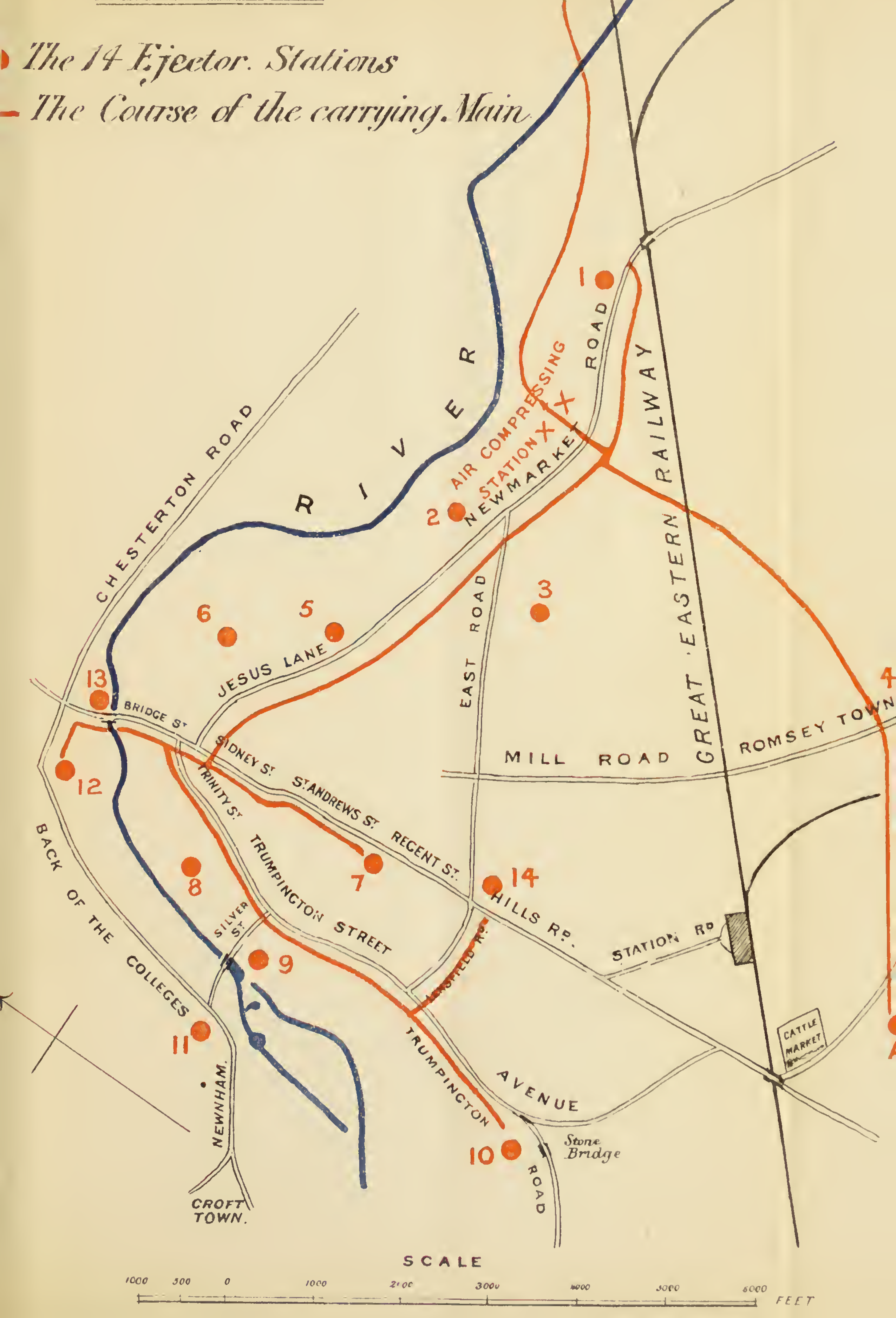
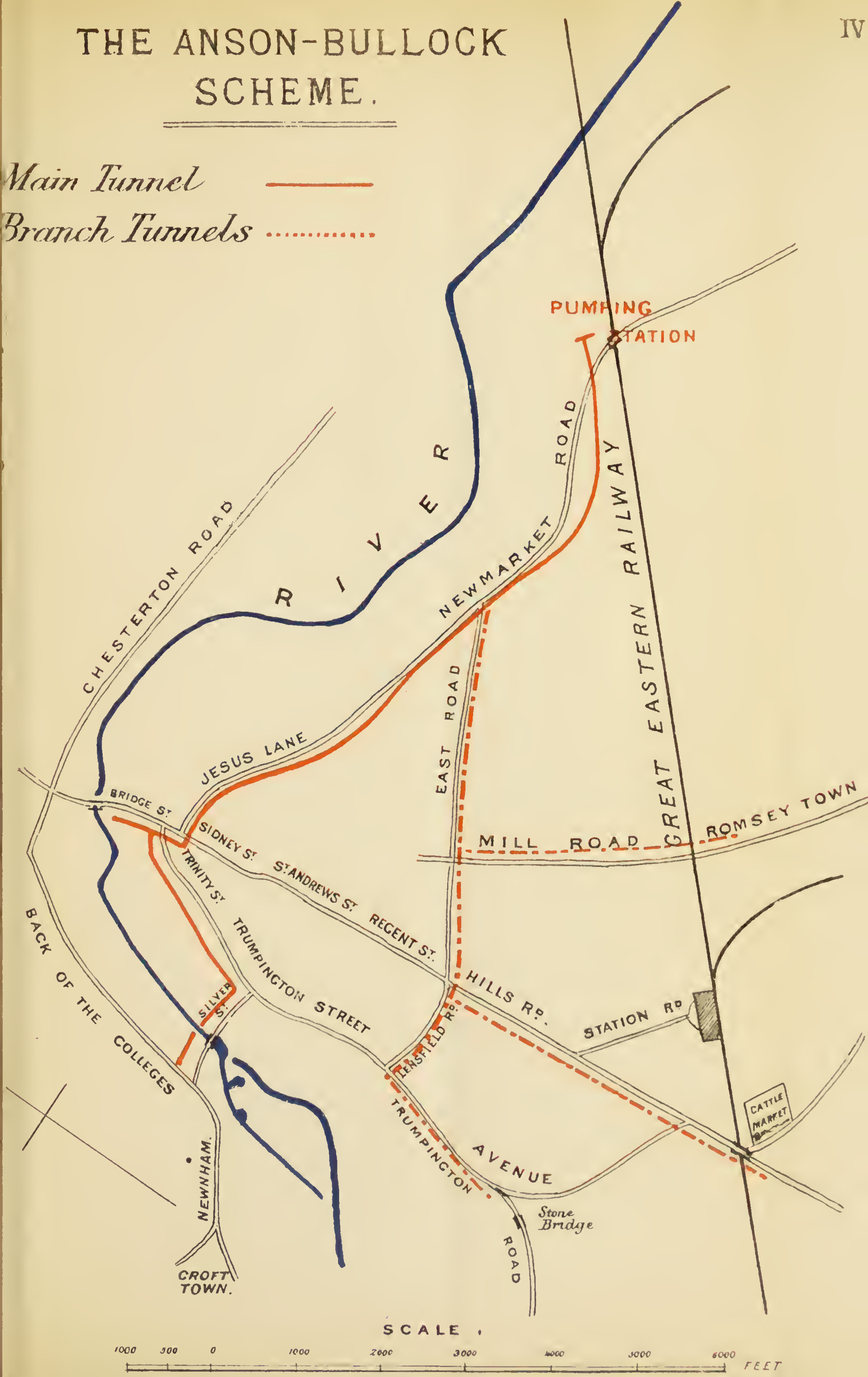
HE DONALDSON-SHONE SCHEME.

● *The 14 Ejector. Stations*

— *The Course of the carrying. Main*



THE ANSON-BULLOCK SCHEME.



THE MAIN-DRAINAGE SCHEMES
FOR CAMBRIDGE.

CHAPTER I.

INTRODUCTORY.

By "the Rivers Pollution Prevention Act" of 1876, the causing or knowingly permitting to flow into any stream any liquid sewage (except so diluted as to be harmless), was made an offence rendering the Sanitary Authority liable to be informed against, to have heavy daily penalties imposed on them, and to have the obligation to comply with the Law enforced against them. Ten years have elapsed since this Act was passed, and during the whole period it may be said that the question of complying with it in Cambridge has, in one form or another, been continuously under the consideration of the Local Sanitary Authority. Latterly whilst the pressure of public opinion and the evident exhaustion of the patience of the Local Government Board have brought it into a more acute stage, the development of the rival schemes has added considerably to its interest and importance. The financial difficulty which has so long blocked the way, based upon the feeling that in Rating and Valuing the University and Town Properties both should be treated by the same authority and on the same principles, has now been removed by the agreement come to between the Commissioners and the University; and it may be fairly hoped that we have now also arrived at the point of time when it is possible to say, so far as the relative exponents of the rival schemes are concerned, that they have each said their respective last words, and that the three schemes can now be considered as fully developed and ripe for criticism, experiment, and final judgment.

Under these circumstances it may not be unacceptable to the ratepayers to have the three schemes stripped, as far as possible, of technicalities and overburdening detail, and presented to them by way of contrast and comparison. Having had tediously to grope my way for three years through the baffling and shifting stages of each scheme as it has been presented, modified, re-arranged, or extended to meet the exigencies of the times or the criticisms of the Committee, I may perhaps save my more fortunate readers some of "the heat and burden of the day," and yet at the same time enable them to form a judgment practically as ripe as if they had had a more laborious share in the consideration of the schemes stage by stage.

It goes without saying that no subject of like importance has ever before engaged the attention of the local authorities, or has demanded and still now demands the greatest amount of careful attention, and the most severe criticism which can be provoked by the widest possible publication of the proposals submitted for dealing with it. No engineering subject has hitherto so taxed the skill of the best heads in the country, no subject has had such diverse and such dogmatic advocates; and no subject has, in other towns, ended in such signal failures. We have not far to go to see instances where hundreds of thousands of pounds have been spent only to produce a condition of things worse than that which pre-existed, where indeed the remedy has been worse than the disease. In few cases can success be said to have been achieved, and in all, it may with truth be said, an outlay has been incurred considerably exceeding the most sanguine estimate. We are the heirs of experience in this matter, and it behoves us that, as we must mortgage posterity to carry it out, we should be sensible of the especial responsibilities attaching to our position as their trustees.

In considering the object to be attained in Cambridge the principal point is not what advantages, not now possessed, can any system of interception give us, but rather it is that we may lose none of the advantages which we now have; for I conceive that as an interceptor the natural and ample water course into which the sewage matter now finds its way by gravitation, without let or hindrance, can never be bettered; and if it were not that the duty is imperatively imposed upon us by Act of Parliament, I apprehend it would never occur to any reasonable being to provide any other channel than the river, for none can possibly be provided which for situation, capacity, and results are likely to be more satisfactory.

The river is a receptacle capable at all times and under the ever varying circumstances of each hour and day of receiving and removing out of the Town the sewage and rain water produced in the Town area; and it is phenomenal if once in 20 years the sewage and rainfall come with such rapidity as not to be capable of being carried away in time to prevent any overflow into house areas—[excepting, indeed, one very small district in the neighbourhood of Hills-road, where the bungling designer of recent years has placed his basements below the old sewer level].

This being so it becomes a matter of importance that the scheme adopted should be able to receive and remove the sewage and rainfall at all times and in any varying quantity with at least as much certainty as the river. The depth, inclination, and direction of the existing sewers is a matter of some obscurity and conjecture, but one fact is clear, that all the existing sewers do finally find their way into the river at a series of points commencing at Mill Lane where the sewage of New Town and Trumpington Street is discharged; at Silver Street, where the sewage of Pembroke Street and an area to the right and left is discharged; at Garret Hostel lane, where the sewage of Trinity Street and adjacents is discharged; at the Great Bridge, where as far as can be ascertained on the one side the sewage from Hyde Park Corner onwards is discharged; at Jesus Green Locks, where St. Clement's parish sewage is discharged; at nearly opposite the Trinity Boat House, where the great King Street sewer empties itself; at near Parsonage Street, where the West Barnwell sewers fall into the river; and ending at Abbey closes, where the sewage from the Station Road down East Road empties itself into the river.

To set against the advantage of the river as an adequate and elastic receptacle there is, in the existing system, a very serious disadvantage, in this that the mouths of the sewers being all in the river, and the area to be drained being only a few feet above that level at any point, the existing sewers must of necessity be extremely flat, and as a consequence, the flow in them must be extremely sluggish. The greatest sluggishness occurring at the periods of greatest drought and heat must needs lead to a corresponding fermentation in certain zones of the town; in these zones, as the Medical Officer has frequently pointed out, there exists a low state of health, certain diseases continually lurking and prowling for the "weaklings" of these areas. Furthermore, areas have grown up beyond the limits reached by existing sewers, and incapable of being drained into them by reason of the head of the sewer in these remote districts being too near the surface to allow of any further elongation.

The new system must therefore not only provide an efficient outfall, but must be prepared to deal with the, at present, built on but undrained areas, and some areas which will, in the not far distant future, be practically part of the Town, and which it is most desirable shall commend themselves for their salubrity as residential areas to that apparently increasing class who are intending, if the surroundings be sufficiently attractive and healthy, to make Cambridge their permanent abode. In this class of areas may be included the Trumpington Road, the Cherryhinton Estates, that important residential area lying beyond the back of the Colleges from the Barton Road to the Huntingdon Road, and, last but not least, that more humble, but for that reason more important area, now commonly known as Romsey Town. The authorities concerned have had no lack of advisers, for in addition to schemes submitted to them by Sir Joseph Bazalgette, C.E., Messrs. Law & Chatterton, C.E., Mr. Wm. Donaldson, C.E., Mr. F. H. Anson, C.E., they have had at one time or another the opinion and reports of others of great eminence in the engineering world, viz.: Mr. Thomas Hawkesley, C.E., Mr. Bailey Denton, C.E., Mr. Bateman, C.E., and Mr. Reynolds Rowe, C.E.; whilst on various questions into which mathematics and its allied sciences entered, they have had the advantage not only of members of the University accustomed to the consideration of these subjects on the Special Committee of the Improvement Board, but the co-operation of a committee of experts (members of the University), outside the Special Committee. It is the very bulk of these accumulated facts which makes it desirable that a description evolved from them and clothed in a non-scientific garb should now be attempted.

CHAPTER II.

THE INTERCEPTION.

Having thus briefly sketched the advantages to be retained and the past omissions now to be made good, we can proceed to detail the three rival schemes, first as schemes of interception and then as schemes of dealing with the intercepted product; and as each scheme, although developed in two instances at least over a period to be reckoned by years, may be considered without any regard to their stages of progress and as being complete to date, we will consider them without regard to their chronological births, and take first the scheme of Sir J. Bazalgette and his co-operators, Messrs. Law and Chatterton. This scheme, for convenience, we will call the Bazalgette-Law Scheme. Under this scheme all the existing sewers will remain, with the exception that Sidney Street will be relieved by a new deep sewer from Sidney Street to the deep sewer existing in King Street, and Hills Road be relieved by a new sewer to supersede the existing sewer, commencing at the end of Station Road, and proceeding *viâ* Hills Road and East Road to join the existing deep sewer in the Abbey Closes, Newmarket Road.

The sewers now discharging into the Mill pit and under the Silver Street Bridge are to be picked up and carried under the river to the corner of Queens' Green. The sewer now discharging at Garret Hostel Bridge is to be taken under the river to the road at the Back of the Colleges.

The main new sewer will commence at Barton Road corner, and passing through Newnham will receive the Silver Street sewer, any sewers hereafter brought to it from Newnham College, Ridley Hall, Selwyn and the Grange Road at the back of King's; thence it will pick up the Garret Hostel sewer and pass by a tunnel under Northampton Street, picking up presumably the sewage of Magdalene Street from the river to the corner of Northampton Street on its right flank, and the sewage of Castle End on its left flank. It will go thence, still by tunnel, along and under the Chesterton Lane, and under the river a little above the Locks. When once on the Common, it will pick up the sewer now discharging at the Great Bridge, which will be diverted through the Quay Side to it, and thence it will pick up on the river margin the series of sewers discharging themselves into the river from the Locks to Barnwell Pool, and an additional sewer proposed to be made from the Cattle Market across Romsey Town, shown on the accompanying plan, and another lower down the Cherryhinton Road to the Romsey Town sewer, not shown on plan, to proceed *viâ* Coldham Lane, falling into the main intercepting or pick-up sewer on Stourbridge Common. Thence the main intercepting sewer will go under the river to the pumping station just this side of the Railway Bridge. This concludes the circuit, with an exception which could not conveniently be mentioned before, namely, the proposal to bring the sewerage of the Trumpington Road down Chaucer Road (the first road over the Stone Bridge), under the river above Sheep's Green, and by means of a gas engine in Croft Town, pump it into the head of the main new intercepting sewer at the Barton Road corner.

The main intercepting sewer would commence at Barton Road corner with a 15-inch stoneware pipe, and at Silver Street corner would be converted into an egg-shaped sewer 24 inches bv 36 inches of 4½ brick-work, surrounded by concrete, have an inclination of one yard in one thousand and a velocity varying with the bulk of its contents from about 1¾ft. to 2¾ft. per second. After passing Magdalene Street the size is increased to 26 in. by 39 in., and after receiving the Great Bridge sewage on the Common to 32 in. by 48in. It then picks up other sewers and is increased to 34 in. by 51 in., and the inclination decreases to one foot in 1200 and one in 1300. Along the towpath the size is increased to 36 in. by 54 in., which is its superior limit, after having received all that it is intended to carry, and the inclination is decreased to a fall of one foot in 1500. In other words, this sewer of 36 inches by 54 inches is to take the place of the river and be the receptacle to meet every strain which the town or the elements may place upon it.

In order to have the advantage of the salutary influence, upon the shallow sewers, of the admission of pure water, the Bazalgette-Law system proposes not to exclude Hobson's stream, but to carry that to the estimated extent of 750,000 gallons per day.

We have now got the whole of the sewers, whether old or new, whether sewers of collection or interception, to one grand focus or point at the pumping station ; and now let us see what daily bulk will at that point press for passage.

	Gallons.
1st, We have the sewage matter of a population which is calculated at 50,000 individuals at 25 gallons per head per day ; this gives us a quantity equal per day to	2,500,000
2nd, Hobson's water, which is necessary for flushing, equal per day to ...	750,000
3rd, Underground water finding its way into the sewers by leakage, 240,000 *gls.*, say	250,000
Constant quantity equal per day to	3,000,000
There remains the rain water falling upon paved and impervious roads, paths and buildings ; the extreme quantity provided for is 1 inch of rain on 600 acres, which would equal 13,608,000 gallons, but it is assumed (and about this assumption I shall presently have some remarks to make) that only one-half will find its way into the sewers, and adopting the presumption we have a bulk which on certain days may equal	6,810,000
Giving a grand total said to be provided for passing through the pump of ...	9,810,000
If the whole rainfall on impervious roads, paths, yards and buildings of the 600 acres, equalling one inch in any day passed down to the pumping station,—a	

far more likely event,—(for exactly as the rainfall is heavier so a larger proportion find its way into the sewers), there would be another bulk of	6,810,000
Or a total of	16,620,000

To deal with the bulk waiting at the Pumping Station to be transmitted, Sir Joseph's scheme provides "two compound condensing engines, each of 44 horse-power and "capable of lifting 500 cubic feet per minute" to the necessary height.

The capital cost of the scheme *to this point*, i.e., to the pumping station, including pumping power, is estimated as follows:

Intercepting sewers, pumping station, engines, engine house, &c., branch sewer for Cattle Market and Romsey Town, and relief sewer from Station Road to Newmarket Road	£48,722
To this must be added some *evident* omissions, viz.:	
The cost of turning the sewers now running from Northampton Street with an incline *to* the river, so as to have an inclination *from* the river to the corner of Northampton Street, where the tunnel sewer takes it at a depth of some 18 feet ...	£
The cost of the relief sewer from Sidney Street to King Street corner ...	£
The cost of acquiring the right to lay a sewer across private property from the Cattle Market to Romsey Town ...	£

I think the above fairly and accurately describes the proposals of the Bazalgette-Law scheme for accumulating and passing out of the sewers the bulks to be dealt with and the cost to that point. It now remains to point out what appear to be the advantages and disadvantages of the scheme as an intercepting scheme.

Its advantages and strong points are :

It utilizes all existing sewers as sewers of collection, and thereby avoids the expense and inconvenience of grubbing up the whole town.

It requires no mechanical effort to get the bulk to the pumping station ; the unfailing law of gravitation being relied on.

It gathers within its scope all the probable or possible areas required.

Its disadvantages are :

It gives no relief to the existing long low flat sewers, which are known to be in many parts in a clogged and dangerous condition, and necessitates their being made longer and as flat ; even the new sewer from Barton Road corner to the pumping station, in a length of nearly four miles, has only an inclination varying from one foot in a thousand to one in fifteen hundred feet.

This flatness makes it necessary to pass through the sewers the Hobson's Stream waters and the daily pumping of its bulk of three-quarters of a million of gallons, but then this water can only be passed through *certain* sewers, and as is pointed out in the scheme the reason for taking the water in the sewer is, that unless it is so used "the dry "weather flow would not be sufficient to prevent "deposit taking place in the sewer, and the genera-"tion of noisome gases which would find their way "into the houses." We may accept this graphic picture as true, but what is the conclusion to which this unerringly points ? Why, that those portions of the sewers which cannot have the Hobson's flush, will either be pest traps, or must be the source of "considerable expense for cleaning."

It makes an utterly inadequate estimate of the amount of rainfall to be dealt with, viz., that on an area of 600 acres only *one-half* of the rain falling will find its way into the sewers. The total area of the Borough is 3278 acres, and the estimate of 600 acres means that there are 600 acres of this extent with impervious roads, paths, paved yards, and covered courts or buildings, and I think the estimate is fairly accurate, for I have tested it somewhat minutely. But upon what evidence the estimate is based, that only one-half the rain falling upon this impervious area will find its way into the sewers I cannot for the life of me see. Such an estimate may be justifiable when the rainfall comes in showers, for then evaporation would absorb much of it ; but it is exactly in proportion to the heaviness of the fall that the bulk finding its way into the sewers increases in ratio, and it is for the heavy falls, up to one inch per day, that provision is said to be made. I think this assumption of one-half is under-estimated to the most serious extent, so serious indeed, as to represent either 6,810,000 gallons in a day, or 13,620,000 ; for if an inch a day falls and all of it finds its way into the sewers, the latter figure will have to be dealt with ; if the estimate of only half finding its way in, then the former figure will have to be dealt with.

No provision is made for the overflow. There is a statement that it is "to be discharged into the river." But where ? Clearly it must be capable of being passed into the river directly out of the sewer at a point where the sewer is above the level of the river bed. The earliest point this occurs, if it occurs anywhere, is on the Chesterton side of the river above Jesus Green sluice ; but at this point the main bulk of the sewage will not have entered the sewer, for it is only when it gets below the Sluice on to the Common that it begins really to pick up any appreciable quantity. My pen was running on with some observations on what should be the conditions imperative of a storm overflow, but I omit them, as we are now dealing with a scheme as it is and not as it might have been. It is useless to discuss the nature of provisions where no provision at all is made. Mr. Donaldson says, with considerable elaboration, that *none can possibly be made.*

It further appears to me that an absolutely inadequate provision is made to pass away even the quantity which is estimated to be pressing for passage at the pumping station (low beyond acceptance as I take that estimate to be) ; but accepting it, what do we find ?

A quantity made up as follows :	Gallons.
Daily sewage	2,500,000
Daily Hobson's water	750,000
Daily soak subterranean water ...	250,000
	3,000,000
Estimated fall of 1 inch on 600 acres, of which *only half* is estimated to pass into the sewers (one-half is)	6,810,000
	9,810,000

And how is this to be passed on ? There is provided for this "two compound condensing engines each of 44 horse "power capable of lifting 500 cubic feet per minute," to the necessary height. Reduce this to a sum, and you prove the provision for passing on the bulk to be glaringly insufficient :

500 cubic feet per minute.
$6\frac{1}{4}$ gallons in one cubic foot (nearly).

3,000
125

3,125 gallons lifted per minute.
1,440 minutes in 24 hours.

125,000
12,500
3,125

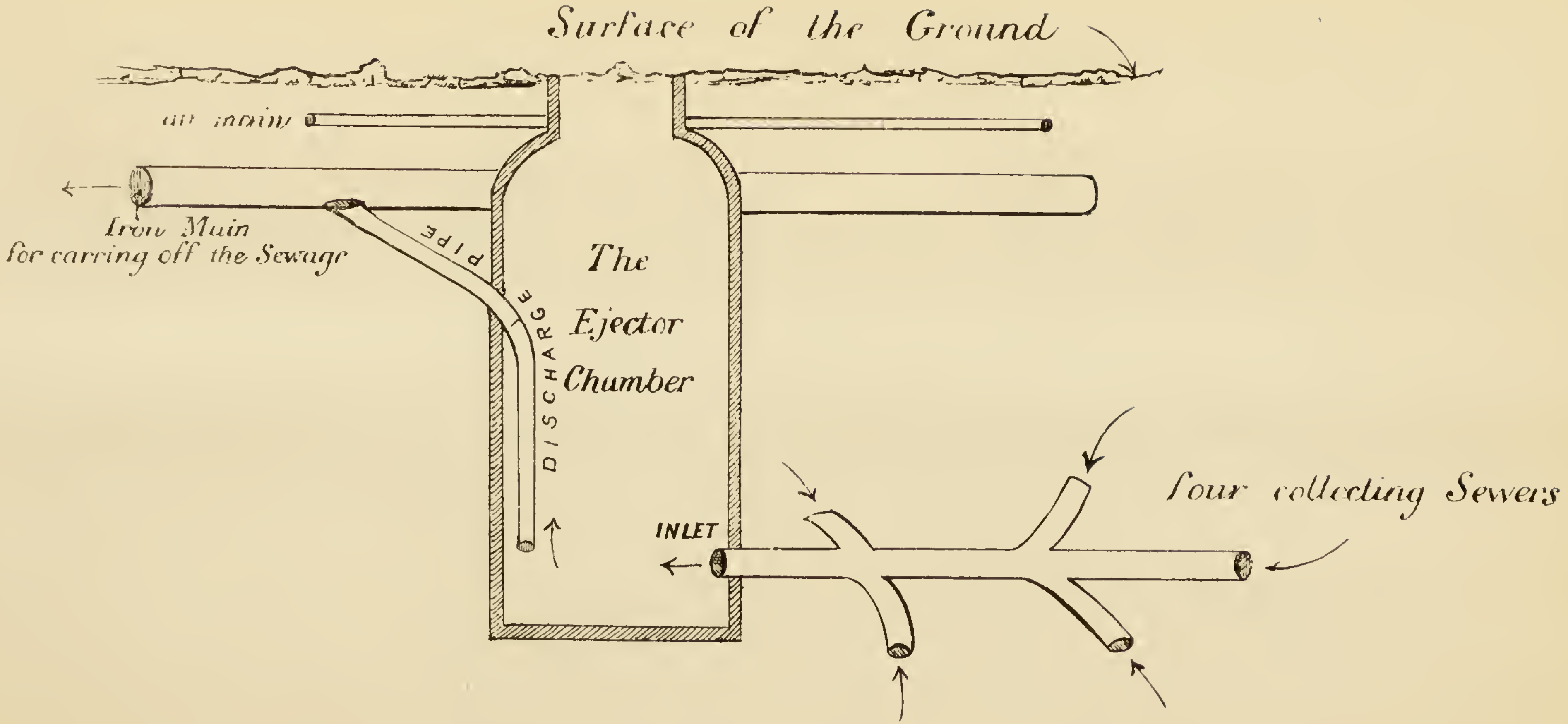
4,500,000 total pumping capacity working both pumps every minute of the 24 hours is less than half the work to be done.

But the capability of passing on the rainfall in such a way as to ensure that there be no backing up into the basements seems to me to rest on yet another *assumption,* namely, that if the inch of rain provided for, instead of being spread equally over the 24 hours falls in an hour, the call upon the pumping "would be equalised by the varying distance that "the rain had had to travel from different parts of the "district." No reliance can be placed on such a possibility, or rather such an impossibility, for the main intercepting sewer being roughly in the shape of a segment of a circle into which the gathering drains impinge as from the centre, like the spokes into the tyres of a wheel, very little of the rainfall has any really considerable distance to travel, and the whole must certainly reach the pumping station in two hours.

And under these circumstances the storage capacity of the sewers is deficient. It must be remembered (and it is pointed out before) as the one great advantage of the river over any possible scheme to be devised in its place, that its capacity of reception is unlimited and the flow of it unchecked. In the place of that we have a flow which must be checked at the pumping station and must be limited by the pumping power. It therefore follows that to meet emergencies the storage capacity of the sewers should be large : but the storage capacity of all the Bazalgette-Law interception sewers is only equal to 650,000 gallons, and it is demonstrable that the rainfall and sewage would under many circumstances overpower the pumping and storage, with an absolute certainty of frequent sewage floods in the town. Here it may not be out of place to record that last night (Sunday, the 25th July, 1886) there fell 1¼in. of rain in Cambridge in little more than 3 hours ; on the the night of the 3rd August, 1879, I remember 3¼ inches of rain falling in the same period of time ; and on the 25th June, 1883, I have good reason to remember that nearly an inch of rain fell between 11 a.m. and noon, and 2¼ inches fell between 11 a.m. and 3.30 p.m.

Hitherto my task has been extremely simple, for all the apparatus, if such a term may be used, employed by Messrs.

On August 17, 1886, as this publication was passing through the press, nearly an inch and a half of rain fell in three hours, representing a volume of nearly twenty millions of gallons on 600 acres. It is almost needless to say that this overpowered even the capacity of the present outfalls and complaints of flooded areas were more numerous than usual.


Surface of the Ground
air main
Iron Main
for carring off the Sewage
The
Ejector
Chamber
DISCHARGE PIPE
INLET
four collecting Sewers

Bazalgette & Law are simple and so commonplace as to need naming only and not describing. Not so the next scheme which I propose to endeavour to explain, viz., the Donaldson-Shone scheme, for in that everything is novel and highly technical. They propose in the first place to separate the rainfall, as far as possible, from the sewage, and the special Drainage Committee, after full enquiry, felt themselves compelled to adopt this view, as of necessity a part of it. This separation would be effected by leaving the existing sewers to carry off the street rain, and by laying 48,742 linear yards of new 7 or 9 inch pipe sewers, to be newly connected with the houses. The estimated cost of this preliminary and necessary condition is £33,200.

These new sewers would be laid in 14 defined areas, the sewer pipes in each of such sub-areas converging to a common centre ; as for instance, all the sewer pipes of the Avenue would converge to the Stone Bridge ; all the sewers from the Railway Bridge, Hills Road, and the streets on the right coming from the Railway would converge at Hyde Park Corner ; and so on all over the town. The centres of the 14 areas are indicated on the plan annexed. These collecting sewers will be pipes laid at a self-cleansing gradient of one foot in 300 feet.

There is no doubt that by this system the smallest quantity of the sewage matter would have to be dealt with, and it would be sewage matter in its most undiluted form. The question will naturally arise,—How, when it has congregated in 14 centres, are you going to provide for its storage and passage away ? And herein is the essential novelty of the Donaldson-Shone system. The proposal is to connect these 14 centres by an iron main which shall pick them all up on the route shown on the plan by a red line. This collecting main would commence at the Stone Bridge on Trumpington Road with an iron pipe 7 inches in diameter, and increasing as it goes to a diameter of 9, 12, 13, 14, 15, 19, 20 inches, ultimately at its end being 21 inches.

The point still remains, How are you going to get the sewage out of the new collecting sewers into the iron, if I may so call it, "travelling main"? This can really only be illustrated by a drawing, which I give in the margin, with apologies to the more expert draughtsman for omitting details. It suffices if it illustrate my text to laymen.

At each of the 14 points the sewage will pass through an inlet 6 inches in diameter into a chamber called an Ejector, and by the only reliable course out of the three submitted, "Compressed air," is sent through a system of pipes from a central engine fixed at River Lane to the 14 points, where the 14 chambers collecting the sewage are. As soon as a chamber is full the compressed air valve opens of its own accord; compressed air is let in on the top of the sewage, forces it up the discharge pipe into the carrying main, and gives it sufficient impulse to send it to the sewage works, where it is to be dealt with. Directly the chamber is empty the valve shuts off the compressed air, and opens the exhaust hole through which the compressed air (having done its work of pushing out the sewage) escapes; the chamber then of course fills with air at ordinary pressure, and the sewage begins to run into it again, as it rises of course pushing out the air. When it is filled again, on the top of it comes the compressed air, and so it goes on as long as the compressed air is sent out from the central engine. Each process of filling and emptying would occupy one minute of time, and whilst the chamber is being emptied the sewage will be accumulating in the collecting pipes.

The case of heavy rains is suggested to be met by overflow at each ejector station into the existing sewers, and thence into the river.

The estimated cost of the system of iron carrying mains, compressed air pipes, ejector chambers, and air compressing machinery is £37,786; the cost of the collecting sewers has already been stated as estimated at £33,200.

Such is the Donaldson-Shone as an intercepting scheme, and now let us consider it from various points of view. Its one great advantage is that it would, by partially separating rainfall from sewage, materially diminish the bulk to be dealt with at the delivery on to the sewage ground; but I question whether Mr. Donaldson has not been over sanguine as to the effect of leaving all existing sewers in to carry off rainfall, and as to the quantity which will still be left to be carried by his new sewers. He estimates that instead of the rainfall of 600 acres, the rainfall of 100 acres only will still find its way into the new sewers. I estimate a very much larger quantity of rainfall will still pass into the sewer. It is true that each house is practically or actually to be connected with this new sewer and, in theory, only such bulk as comes through its closets and sinks ought to find its way in, but as a matter of fact in most cases all the rain water which falls upon the back of the house and outbuildings and in many cases the rain falling upon the back paved yards goes into the closet soil pipe and must continue to do so. It is so in the house in which I live ; it was in the last house that I occupied, and I know is so in many others. So that practically what is got rid of by the separation is only the water falling on the streets and the *fronts* of the house roofs.

The rainfall which would still have to pass through the ejectors is open to the same observations as to the uncertainty of its quantity and of the period at which it would fall already made in considering the Bazalgette-Law scheme. It is true that no similar danger would arise from want of overflow in this scheme as in that, for the scheme provides that at every ejector station there shall be means of overflow into the existing sewers, and hence, as now, into the river when there is a storm or when any of the machinery of the scheme is under repair. One great objection to the scheme is, in fact, that either from excess of rain, pressure of flow to the ejectors, stoppage of works, or desire to economise the cost of pumping, the overflows into the river will be so constantly called in aid as to, after all, be the real drainage system, and the value of the proposed expenditure be entirely neutralised, with this additional fact that *no one but the foreman of the pumping station* could tell when the sewage was passing into the river and when it was not—a most serious incident !

It is not at all clear to me how anything but a most regular flow of liquid is to get into the ejector chamber with sufficient certainty and rapidity to prevent the sewers getting overflowing full, for the inlet is a 6 or 8 inch pipe.

Difficulties would arise from such foreign matters as scrubbing brushes, house flannels, towels, and a hundred and one things which unaccountably do get into a sewer, and these ask for admittance through the inlet pipe of the ejector chamber and not getting it, there would follow an overflow to the existing sewer. I must also call attention to facts connected with the inlet and outlet *of air* into and out of these ejector chambers. In the first place, the sewage admitted into them is nearly in a state of nature, that is to say, in the absence of rain it is very undiluted: it is let into the ejector chamber, having been kept waiting a greater or less time, and then it is driven out by compressed air. So far, so good. But then two substances cannot be in the same place at the same time, and so long as the compressed air occupies the chamber the next charge of sewage cannot enter: so it is arranged that a valve opens, and the compressed air, having been in contact with the sewage matter and the reeking walls of the chamber, shall be let out into the street. But that is not all. As the compressed air rushes out air at ordinary pressure takes its place, and this in its turn, as the sewage fills up the chamber, having been in contact with it, is also pushed up into the street. So that in fact once every minute a bulk of air equal to two volumes of the sewage is discharged into the street out of the sewage ejector station. It is true that to meet this evident criticism the Engineer did at a late stage state that he had, as a second and alternative plan, *invented* an automatic pump to be used, which prevented the air coming into contact with the sewage; but at that time it remained an invention, and was not at work, and he in rather a fugitive way suggested as a third alternative that the motive power could then be compressed water instead of compressed air. But he can hardly expect the Commissioners to entrust the work to an untried experimental invention, and I have treated the Shone ejector as Mr. Donaldson has always treated it—as his real and serious intention. It will be of course seen at once also that the power of moving the sewage on from station to station, all other things being in perfect order, depends upon the valves at each ejector being in perfect order and the inlet clear; to ensure this, it will be necessary for the foreman to visit each ejector once a day, and a scavenger to go down to each chamber once a day to clear out the accumulation of paper, grit, &c.; a remissness of either of these would throw the scheme out of gear.

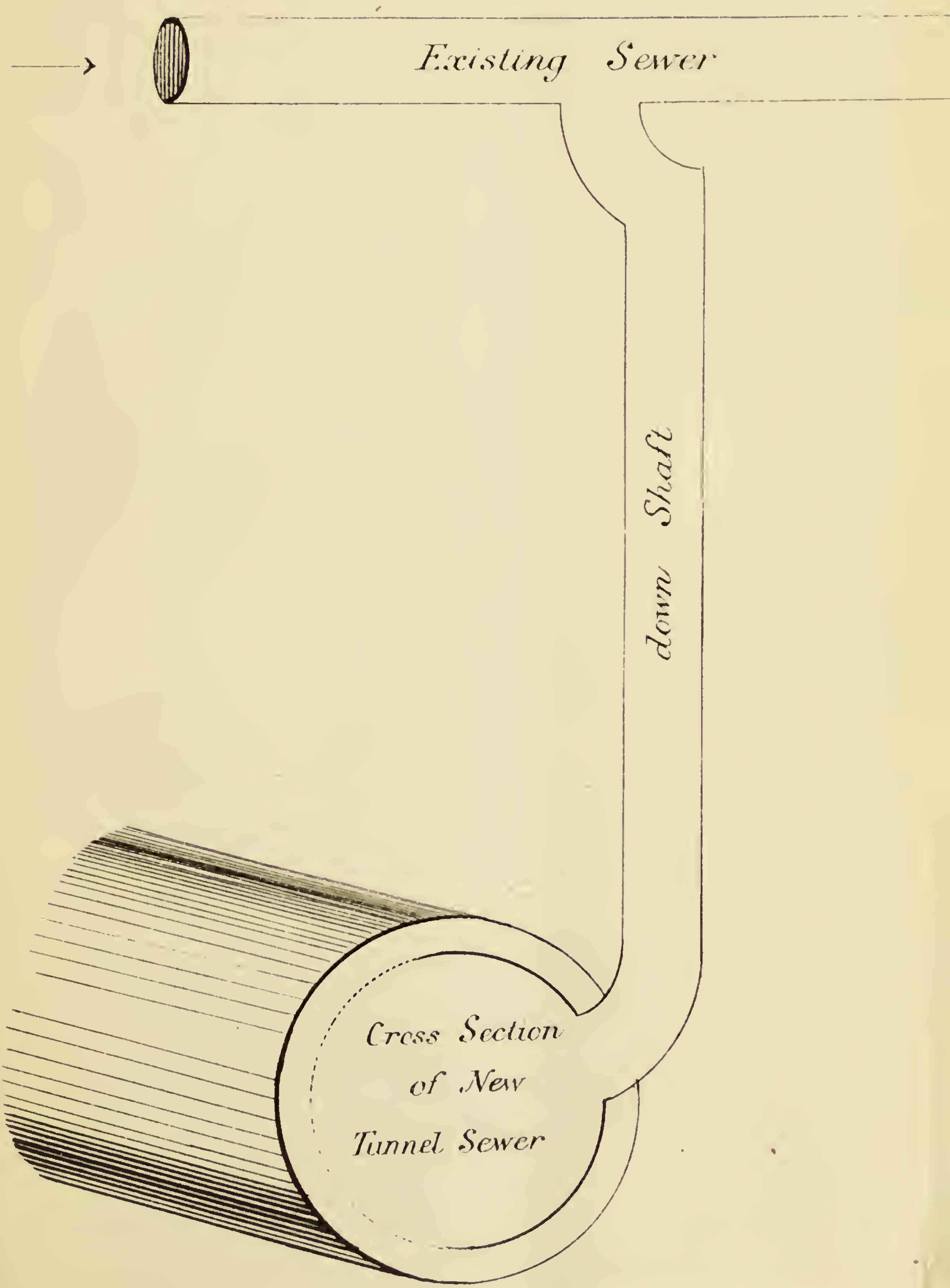
Such is the Donaldson-Shone scheme, for imprisoning and carrying to a particular point the sewage, and I have stated the cost at his estimate. There is one point in this question however, based on an assumption, which will cause an increase, and that is, that there would only need to be made 2000 new connections between the existing houses and the new sewers. This assumption is based on another, that in frequent cases whole rows of houses are now connected with the sewers by one or two connections, whereas such is the case only in a very few instances. In the great bulk of cases each house has, and must in the new scheme have, a separate connection. I apprehend that the number of connections will be at least double the estimated number. Mr. R. R. Rowe, a former town surveyor, estimates it will be trebled. The Committee have taken the medium as their estimate, and say 5000 at a cost of 30*s.* each, which increases the estimated cost by £5000.

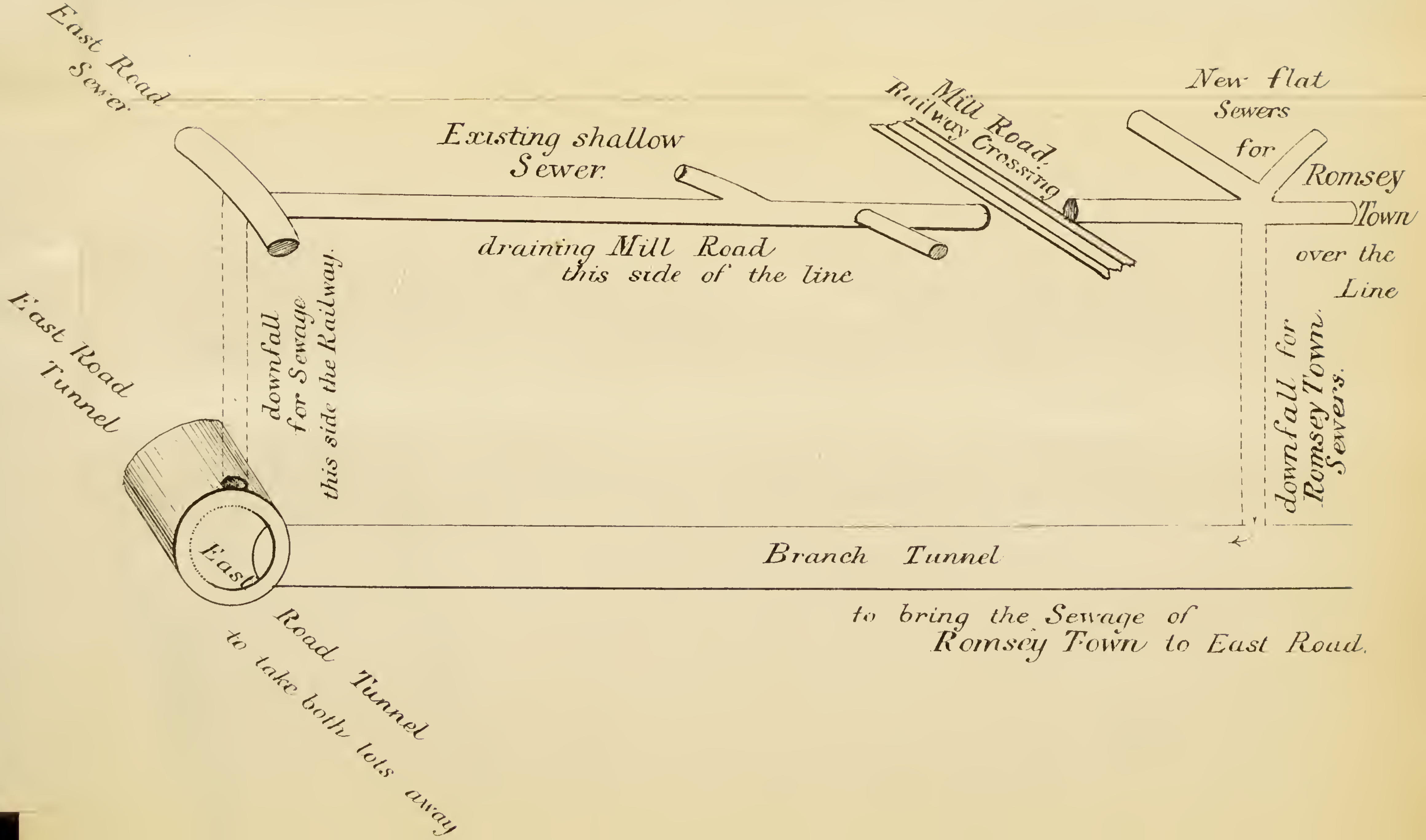
With these observations, which I think deal with all the main points of the Donaldson-Shone scheme as a scheme of interception, we may leave that scheme and pass to the Anson-Bullock scheme, popularly known as the Tunnel Scheme, and consider that as an intercepting scheme.

By that scheme all the present sewers would be used for their present purposes, and a series of three intercepting sewers would be tunnelled in the gault at such a depth as to allow the whole of the contents of the existing and new shallow sewers to fall into the tunnel sewer and be carried to the pumping station by gravitation. In this scheme there is no mechanical contrivance whatever, except, of course, the pump at the pumping station to pass the sewage on to the land. The blue gault is the material out of which the Cambridge bricks are manufactured; it can be seen exposed at the various brickfields on all sides of the town ; it is easily excavated, is impervious to water, and is believed to lay in an unbroken statum some 10 to 15 feet below the surface, and to be about 120 feet thick. All past experience in well sinking and other excavations concur to establish these facts.

The first line of interception would be a tunnel commencing at Queens' Green corner, at a depth of 23 feet, where there would be poured or rather dropped from above into it the sewage brought by ordinary shallow sewers in the ordinary way, from Croft Town, Newnham Colleges, and the Grange and West Roads. The tunnel passes under and along the line of Silver Street, where at its junction with Trumpington Street there would fall into it the sewage which now comes down that street in the existing shallow sewer. The manner of the sewage getting out of the existing shallow sewer into the tunnel sewer is simply that of falling. [The annexed sketch shows one of the downfall shafts connecting the upper sewer with the lower sewer in tunnel.] The tunnel would then pass along Trinity Street, where the sewer coming down Rose Crescent and now going down Garret Hostel Lane, would fall into it ; down St. John's Street, where at the corner the sewers coming from Sidney street and from the Bridge would fall into it ; thence down Jesus Lane where, as they cross it respectively at Manor Street, Four Lamps, Fair Street, and Parsonage Street, the sewers now running across the Common into the river would fall into it. This tunnel would range from 4 to 5 feet in diameter, and would have a fall ranging from 9 feet to 15 feet to the mile.

Another tunnel would start out of the one above described, at the junction of Newmarket Road with East Road, and pass at an inclination of 20 feet per mile along and under that road its whole length from East Road corner to the Conduit Head corner in Trumpington Street. At Panton Street the sewer there would fall into it, and flow down the East Road, instead of, as now, flowing down Trumpington Street. At Hyde Park Corner the Hills Road sewer would fall into it, and flow the same way. At Mill Road corner that sewer would fall into it and flow away,


Existing Sewer
down Shaft
Cross Section
of New
Tunnel Sewer


East Road Sewer.
Existing shallow Sewer.
Mill Road. Railway Crossing
New flat Sewers for Romsey Town over the Line
draining Mill Road this side of the line
East Road Tunnel
downfall for Sewage this side the Railway.
downfall for Romsey Town Sewers.
East Road Tunnel to take both lots away
Branch Tunnel
to bring the Sewage of Romsey Town to East Road.

and so on for all the cross sewers out of the streets on the right side of East Road.

Another branch tunnel at an inclination of 20 feet in a mile leaves the East Road tunnel at Mill Road corner, and passing along and under that road to its furthest extremity, would bring the sewage of Romsey Town to the East Road tunnel, where it would flow into the tunnel there, and so away. Perhaps that point as well illustrates this dual system of sewers as any point in the Borough, and I subjoin a rough sketch of it. The explanation of the sketch is that there are existing shallow sewers into which the sewage of Mill Road, Covent Garden, Union Road, &c., now falls, *up to the Railway Crossing*, and thence runs into the sewer at the East Road end of Mill Road ; but by the time the East Road sewer gets to Mill Road corner, it is now, in time of rain, quite full with the Hills Road sewage. Under the Anson-Bullock scheme the Hills Road sewage will have gone down into the tunnel at Hyde Park Corner, and at Mill Road end the Mill Road sewage from this side of the Railway will do the same, instead of having to wait till the East Road sewer can carry it, and then have to travel in a very flat and gorged sewer to the river. At present no sewers exist over the Railway Crossing on Mill Road. Under the Anson-Bullock scheme all the sewers to be made there will, on reaching the Railway Crossing, fall into the branch tunnel, and flow under the Mill Road into the main tunnel on East Road.

Another branch tunnel would run from Hyde Park Corner, along and under Hills Road, at an incline of 20 feet in the mile, to the corner of Cherryhinton Road, where there would fall into it all the sewage of the Cattle Market, and if so arranged for, the sewage of the adjacent houses in Trumpington and Cherryhinton parishes, such as Cavendish College, the Rock Estate, &c. ; all this would be passing on in the tunnel, whilst the sewage of Hills Road on the Town side of the Railway would be travelling in the fleet sewer above, to fall into the tunnel at Hyde Park Corner.

Another and final tunnel can, if the Trumpington parish will pay for it, pass from the Conduit Head corner of Trumpington Street to the Stone Bridge on Trumpington Road, where there would fall into it, if so arranged for, the sewage of the houses beyond the Stone Bridge.

All the branches having thus joined the East Road tunnel, and the East Road tunnel having joined the Newmarket Road one, it proceeds thence up the Newmarket Road to a point near the Railway Bridge on the Newmarket Road, where the pumping station is designed to be, and this completes the system as an intercepting system.

The cost of the tunnels, down shafts, and pumping power is estimated by the Engineer at £50,791, but the experimental shaft and tunnel now being made are said to point out that the estimate is considerably more than the actual cost is likely to be ; at present, however, as in other cases, it is only possible to take the Engineer's estimate.

The Anson-Bullock scheme has one advantage which neither of the others possess, inasmuch as it does relieve the existing sewers ; in fact, it converts the most important of these from long flat overcharged sewers into short lengths, and reduces the period during which sewage matter is confined in them by a very appreciable time. Take an instance. Instead of sewage matter travelling, as now, from the Railway Station down Hills Road, East Road, and the Abbey closes, in a sewer of slight inclination, and slowly, it will have only to go slowly to Hyde Park Corner, where it will disappear into the subjacent tunnel, with a fall of 20 feet to the mile, and go at a rapid rate to its destination. And so the Cattle Market and Romsey Town sewage, instead of travelling as in the Bazalgette-Law scheme, *viâ* Coldham Lane, through a long flat sewer of two miles long, with a fall of 2 to 3 feet in a thousand, in the Anson-Bullock scheme it would fall almost *at once* into an ample sewer, with an inclination of nearly 12 feet in a thousand. This feature of the scheme I consider of great value.

It next has a considerable advantage over both the others in its very large storage capacity, an invaluable capacity when dealing with large and sudden quantities of rain for short periods of time. For instance, the tunnels alone will hold over three millions of gallons, and only when these are full and the sewage is held up in the existing sewers, and they also are full, is there any danger of flooding basements. That is, however, a danger which is obviated, as in that case the sewage would flow, as it now does, into the river through the present outfalls. Upon the consideration of which occurs another point, viz., that the sewage, under the Anson-Bullock scheme, *cannot* be diverted into the river, except and until the tunnel is full and the top sewers are called into requisition. By reason of this the dangers incident to the Donaldson-Shone scheme of a *continual recurrence* to the river for relief, and the more serious danger incident to the Bazalgette-Law scheme, of not having any storm overflow into the river at all, are both obviated.

The only drawback to this ample storage is the temptation it will give to let a large bulk remain until one set of pumps can work it off gradually, rather than set two sets going and work it off quickly ; against which may be placed the fact, that when the bulk is large the quality of the sewage is weak, and the additional fact that the height of the sewage at the pumping station is an invarying tell-tale of the quantity to be dealt with. Ignorance can therefore never be pleaded to excuse neglect. The two engines proposed would pump over five million gallons in 24 hours. The dry weather flow for 35,000 is estimated at 1,175,000 ; the pumps could therefore lift nearly four millions of gallons of rain per day in addition. This point must be left to the common sense of our successors. Suffice for us if we provide the means.

CHAPTER III.

THE COST OF PUMPING.

The next point is,—What will be the annual charge incurred in passing the effluent on from the Pumping Station to the land where it is to be treated ? Each scheme includes treatment of it on land nearly in the same position, although they differ materially (as I shall show presently) on the quantity of land required for the treatment.

This question of cost depends, of course, on the quantity to be passed. Now the quantity to be passed depends partly on the quantity coming to the Pumping Station, partly on the quantity which the engines can pass. In the Bazalgette-Law scheme, as we have seen, a larger quantity is likely to come at times than can be passed on. Their engines, working night and day, pass 4½ million gallons, which they estimate would cost £518 a year.

Under the Donaldson-Shone scheme undoubtedly a smaller quantity will have to be dealt with, by reason of the partial exclusion of rain water, and the cost is estimated at £519 a year.

The Anson-Bullock scheme undertakes the greatest bulk, at the apparently greatest depth, and the estimate of the annual charges is £473.

Of course these estimates are most uncertain, and, fortunately, of the least consequence. In practice they will be found to be the most variable. One can estimate bricks and mortar, cement, excavation, and haulage with tolerable accuracy. The quantity and duration of Rainfall, a factor common to all, is alike out of the power of any of them to prognosticate.

CHAPTER IV.

THE MODES OF TREATING THE SEWAGE.

Different as are the modes of getting the bulk together, those differences pale into insignificance before the different modes recommended for treating it so as to get rid of its noxious elements and return the effluent to the river in a sufficiently pure state.

Bazalgette-Law, true to their old love, recommend that, after the removal of the solid matter held in suspension, the effluent shall be purified by Broad Irrigation, which, in the language of "the Second Report of the Commission "on Metropolitan Sewage Discharge, 1884," [than which no more impartial or better authority can be quoted], means

> "the distribution of sewage over a large surface of "ordinary agricultural ground, *having in view* a

> "maximum growth of vegetation, consistently with
> "due purification, for the amount of sewage
> "supplied."

For the purpose of removing the solids it is advised that tanks be made 300 feet long, 90 feet wide and 6 feet deep, in which the sewage, with the solid matter held in suspension as first pumped up, can be treated either by mechanical filtration or by chemical precipitation, the sludge pressed by machinery, and the resulting liquid would be then run on to land, of which it is recommended 400 acres be bought.

No estimate is given in the last report as to the cost of this, but on referring to the report of the year 1879 we find some data enabling an estimate to be framed.

400 acres of land, say at £50 per acre	...	£20,000
Preparing the land, £15 per acre	...	£6,000

On the other hand Sir Thomas Hawkesley, whom the Committee consulted at one stage of their proceedings, estimated that after the land was bought it would require a capital outlay of £150 an acre, or £60,000. On the contra, it is only right to point out that in 1879, Sir Jos. Bazalgette anticipated a rental of £4 per acre, at least, from the farmer of the land. I am not aware that the experience of the seven years which have since elapsed enable us to take anything like so sanguine a rental view.

Mr. Donaldson suggests three courses: the first a patent of his own, called Purification by Atmospheric Oxidisation, which allows the sewage to fall two or three feet through a perforated screen in the form of fine spray, and become thereby saturated with atmospheric air, and so on through other perforated plates. The effluent is then to enter a Shone's ejector, and be forced into the air in the shape of a fountain. Thirdly, the effluent is allowed to rise into a closed chamber, and air is forced among the jets by mechanical means; this process is required to be repeated as many times as is found necessary. An effluent sufficiently pure to pass into a river is described as the result, and when the last or chamber process is necessary, it is suggested that in times of epidemic the air might be heated to any degree, and the sewage "actually boiled," and all the germs of disease effectually "destroyed." This tank and cascade system is estimated to cost £7,000.

I have sometimes wondered whether the whole suggestion was not in fact a practical joke: whether, indeed, Mr. Donaldson had not heard the Shah had been to Cambridge, and was poking fun at us. It seems hardly possible to keep a straight face in considering it. True, it is only a suggestion, and not pressed as an essential.

The second course suggested is not a patent one, but that commonly known as *intermittent filtration*, a system common to the Donaldson-Shone, and to the Anson-Bullock scheme, of which hereafter. The intermittent system cannot be better described than in the language of the Commission "on Metropolitan Sewage Discharge, 1884" as:

> "A concentration of sewage at short intervals on an "area of especially chosen porous ground, as small as "will absorb and cleanse it: not excluding vegeta-"tion, but making the produce of *secondary* "importance."

On this basis 170 acres is stated by Mr. Donaldson to be required, and this, without the land, is estimated to cost £10,800.

Thirdly, Mr. Donaldson frankly gives his opinion. "If "you decide to adopt the *most perfect* means of dealing with "sewage, viz. purification by utilization over wide areas, "it will be necessary to purchase about 500 acres of land; "50 acres as intermittent, and 450 for broad irrigation:" and he estimates, *without the cost of* the land, there will be required an expenditure of £17,000 on this land.

From these we pass to consider the Anson-Bullock proposals, which are to deliver the sewage into open precipitating tanks at the Pumping Station, Newmarket Road, where it will be mixed with lime or any other chemical agent, and in these tanks it will deposit part of the solid matter. The partially pure effluent will then flow *by gravitation* to the land on the other side of the river, and the sludge be swept out every other day and pressed by machinery into dry cakes. Perfect precipitation is stated to occupy six hours, and requires one ton of lime to one million gallons of sewage. Mr. Anson proposes to allow three hours for precipitation, and use 15cwt. of lime per million gallons. The separating and pressing apparatus, which will be at the Pumping Station on the Newmarket Road, near the Railway, is estimated to cost £4250. The effluent, which is sent on to the farm, it is proposed to *again filter* on the before described intermittent principle, for which it is stated 25 acres of land will be sufficient, but he recommends the purchase of 50 acres. The cost of preparing the land, exclusive of its purchase, is estimated at £4500.

Upon the question of treatment (upon which the question of interception in no way depends) much further has to be said and considered, and it does not, for the moment, press. Very valuable information with regard to it is to be found in the "Second Report on the Com-"mission on Metropolitan Sewage Discharge, 1884," which I have quoted, and to which I would refer any reader especially anxious to master this most difficult part of the sewage question. I have sent my copy to the Free Library for reference.

CHAPTER V.

THE ESTIMATED COST.

By way of recapitulation I append the estimates of the cost of each scheme, although I do so with some fear that the figures in such a convenient form are more likely to be quoted than they deserve to be, and the criticisms and exceptions taken to them in the foregoing text forgotten or overlooked. These estimates are really of little or no worth. For instance, as I have pointed out, the Bazalgette-Law estimate of the capital required to be laid out on the Sewage Farm is £15 per acre, whilst Mr. Donaldson estimates it at £30, and Mr. Hawkesley at £150. Again, the Anson-Bullock tunnels are estimated by them to cost £50,791, whilst Messrs. Bazalgette-Law estimate the same work to cost £93,439. On the other hand, it is alleged that experiments in sinking the shafts now progressing point quite the other way, and indicate that the data upon which the cost was worked out was really more than it ought to have been. So again with the Donaldson-Shone, as I have pointed out, the estimate is based on assumptions which only experiment can determine.

The Bazalgette-Law Scheme:

	£
New Sewers, Interception, and Pumping Station	48,722
Mains beyond	6,142
Preparation of Land	6,000
	60,864
Add 400 acres of Land...	

The Donaldson-Shone Scheme:

New Sewers, Interception, and Pumping Station	70,986
Preparation of Land— Either £4,000 £7,000 or £17,000 according as either treatment is selected	
Add cost of Land— Either 5 acres 150 acres or 500 acres	

The Anson-Bullock Scheme:

Intercepting Tunnels & Pumping Station	50,791
Tanks and Filters	4,500
Mains beyond Pumping Station ...	4,500
Preparing Land	4,500
	64,041

I think I have now exhausted the schemes in their most important aspects, and I hope enabled the general public to understand their main advantages and disadvantages. I have attempted to describe their projects in all fairness and impartiality. If I have seemed to press my criticism on any one of them more than another it has been that one scheme has, from one point and one from another, presented itself to me in an aspect calling for the remarks I have made. The subject is far too important to allow either prejudice or smooth speaking to warp the judgment or influence the reason ; and with this observation I submit my effort to elucidate it to the consideration of the Ratepayers.

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